

The Cambridge Companion to
DARWIN

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1 The making of a philosophical naturalist

The law of the succession of types, although subject to some remarkable exceptions, must possess the highest interest to every philosophical naturalist.¹

When Charles Darwin penned these lines in 1837, he was twenty-eight years old, fresh from the *Beagle* voyage, and a self-described 'philosophical naturalist.' As such, he was engaged neither in natural history nor in natural philosophy. Natural history, in the tradition of the Swedish botanist Linné (Linnaeus), concerned the systematic ordering of animals and plants and the discovery of new species. Natural philosophy, in the tradition of Descartes and Newton, concerned the search for general physical laws. Darwin was aligning himself with investigators whose work fell outside these traditions. Some were interested in a comparative anatomy based on ideal forms – the so-called 'transcendental' anatomists, such as the French zoologist Etienne Geoffroy Saint-Hilaire and his Scottish disciple Robert Knox. Others, such as the geologist Charles Lyell, were interested in building comprehensive theories about the earth and its inhabitants.²

Philosophical naturalists spoke of various 'laws of life'. They debated the existence of laws, for example, said to relate taxonomic groupings in regular circular arrangements, as in the so-called quinary system, or to govern organic functions such as the development of the embryo. Another law under discussion was the law of the succession of types. In different areas around the world, it seemed, living species had replaced extinct species of the same kind or type. Living armadillos in South America, for instance, had apparently replaced the armadillo-like creatures fossilised in the rocks of that continent. In the 1830s, patterns like this one, at once biological

and geological, were attracting attention from leading geologists and palaeontologists.

The young Darwin aspired to discover and explain such patterns. Combining the interests of the comparative anatomists and the theoretical geologists, he sought to integrate geology, the study of the distribution of plants and animals (biogeography), and the causal analysis of the processes of biological change. This 'philosophical' perspective was in place before he formulated his evolutionary theory, and provided crucial preconditions for its later development. Indeed, when he wrote in the late 1830s about the succession of types, he had already found the causal explanation he would set out, more than twenty years later, in the *Origin of Species* (1859): that living and extinct species often belong to the same type because they share a common ancestry.³

I EARLY SCIENTIFIC INTERESTS

The outline of Darwin's early life, sketched many times, including twice by himself,⁴ begins with his birth in Shrewsbury in February 1809, the fifth of six children born to Robert Waring and Susannah Wedgwood Darwin. The Darwins' world was one of wealth and privilege, filled with visits to family, country-house balls and matchmaking. The wealth came from both sides of the family, as did the intellectual ambience in which Darwin grew up. From his father, a physician trained at both Leiden and Edinburgh, Charles absorbed something of the ethos of the Scottish medical tradition, in particular its philosophical materialism about life and matter. Equally unorthodox religious and scientific doctrines, including the transmutation of species, had been publicly manifest in the writings of his famous – even notorious – grandfather, the natural philosopher and minor poet Erasmus Darwin. Counterbalancing these tendencies were Charles' mother and his three older sisters Marianne, Caroline and Susan. From them Darwin acquired a Unitarian sensibility that acknowledged a Creator, though not the divinity of Jesus Christ. These different influences from the male and female sides of his family helped define the complex relation he had to conventional religion to the end of his life.

At the age of eight, Charles was enrolled in the school of the local Unitarian minister, the Reverend George Case. Following the death

of his mother in 1817, Charles boarded nearby at the prestigious Shrewsbury School, then under the direction of Samuel Butler. In later life, Darwin recalled the seven years he spent at the school with disgust, characterising its classical education as the nadir of his intellectual development.⁵ Nonetheless, it was there that the boy's precocity and interest in scientific subjects first came to light. Always a passionate collector, he was introduced to more systematic scientific enquiry by his brother Erasmus Alvey. Five years older than Charles, Erasmus had preceded him at Shrewsbury School. After graduation, Erasmus pursued the family medical profession through a new elite route that began with admission to Christ's College, Cambridge, and to the new medical curriculum instituted by John Haviland. As part of this curriculum, Erasmus attended the chemical lectures of James Cumming, who taught the new chemistry of Antoine de Lavoisier and Humphry Davy. Erasmus also attended the mineralogy course of the Reverend John Stevens Henslow, later to become Charles' mentor. Well before Charles himself arrived at Cambridge, he thus acquired from its teachers, through Erasmus, a taste for 'philosophical' pursuits. Together, Charles and Erasmus created their own makeshift chemistry laboratory at Shrewsbury, in which they carried out an array of chemical experiments during school holidays, replicating those enacted in Cumming's lectures. Nearly all of the very earliest surviving letters to Charles are instructions sent from Cambridge by Erasmus, detailing glassware and chemicals to be purchased in preparation for their joint chemical enquiries.

II STUDIES IN EDINBURGH

Following his own graduation from Shrewsbury School, in autumn 1825, at the age of sixteen, Charles travelled with Erasmus to Edinburgh to begin the study of medicine at Edinburgh University medical school. Whereas Erasmus was attending Edinburgh to complete the external degree requirements for the MD in the new Cambridge medical curriculum, their father had decided, in Charles' case, to omit the Cambridge preparation, and enrol him directly in medical school. Rooming together during this first academic year, the brothers read widely in the literature of medicine and natural philosophy, and were soon collecting and studying the marine invertebrates abundant along the shores of the nearby Firth of Forth.

The standard view of these years, drawn largely from Darwin's *Autobiography*, has emphasised Charles' disaffection with his medical studies. But letters and other documents from the time reveal a much more complex picture. Edinburgh was, after all, still known as the 'Athens of the North', and was a place of active controversy over the latest medical and scientific developments, including those that were flooding in from the Continent. Although Charles (and many others) were bored with the famously dreadful lectures of some of his professors, there were several features of the university environment that engaged a young man with precocious scientific interests.

There were opportunities, for example, to advance in chemistry; and in the first term, Charles enrolled in the demonstrative lecture course in chemistry given by Thomas Hope, successor to the chair of chemistry formerly held by the great Joseph Black. Charles enjoyed Hope's lectures very much.⁶ In Hope's lectures he was also exposed to the controversial geological theories of Edinburgh's James Hutton.⁷ Hutton had opposed the so-called 'Neptunist' geological theories of the German mineralogist Abraham Werner. For Hutton, it was not the action of water, but the effects of heat, that formed the geological strata. Such was his enthusiasm for Hope's lectures that Charles remained in Edinburgh after Erasmus' graduation in spring 1826, in order to complete Hope's second series of 'very good Lectures on Electricity', reviewing, among other things, the electrical theories of Charles Dufay and Benjamin Franklin, and the results of recent galvanic experiments on organisms.⁸

In his second year at Edinburgh, Charles' interests shifted decisively away from medical study to more theoretical interests in natural history. In autumn 1826 he enrolled in the intensive, five-day-a-week natural history lectures given by the chairholder in natural history, Robert Jameson. From these lectures, Charles learned about such matters as classification, fossils and the local geology. Around this time he also met the comparative anatomist Robert Edmond Grant, then working as an assistant to Jameson on excursions with students along the beaches and the nearby hills – the most probable context for the meeting of Grant and the young Darwin. It was Grant who had introduced the controversial theories of the French zoologists Geoffroy and Jean Baptiste de Lamarck into Edinburgh discussions. Geoffroy, one of the main architects of the 'Idealist' morphology, had claimed to find structural affinities, or 'unity of type',

between kinds of animals previously classified as belonging to wholly separate taxonomic groups. According to Lamarck, the plants and animals presently existing had arisen through a natural process of transformation, owing to the complexifying properties of the fluids running through their tissues, and the adaptive changes brought about when habits changed in response to altered environments.⁹

Beyond Jameson's lectures and Grant's conversations, there was also the company of like-minded students. In November 1826, Charles was elected to the student Plinian Natural History Society. Sponsored by Jameson, this group consisted mostly of students of medicine, some to become lifelong friends. The regular meetings immersed him in discussions of scientific topics generally, and sometimes of controversial theoretical issues in the life sciences, such as the relations of life and instinct to mental powers, and the relations between asexual propagation and sexual generation.¹⁰ Here Charles presented his first scientific paper, in March 1827. Reporting on the mode of generation in a small colonial marine invertebrate, the bryozoan *Flustra*, Darwin described in detail his microscopic studies of these lowly forms, in which he had found that the ova had the properties of self-motion.¹¹

Darwin's time in Edinburgh proved crucial in several respects. It was there that he first encountered the scientific debates that would engage him as a budding philosophical naturalist. He also developed specific interests in animal physiology, bioelectricity and reproduction. But the most immediate effect of Edinburgh upon Darwin was to deflect him from a career in medicine. When Darwin entered Christ's College, Cambridge, in January 1828, he was en route for a career in the Anglican clergy – a respectable profession for a long line of Cambridge graduates with a passion for natural history and science.

III STUDIES IN CAMBRIDGE

Darwin's student years at Cambridge (January 1828–June 1831) immersed him in a very different intellectual world from the hurly-burly medical environment he had left in Edinburgh. The life of the university was defined by the collection of nearly independent separate colleges, some founded as early as the thirteenth century, governed by boards of celibate Fellows in Anglican orders, with

college life still retaining some of the monastic character of its medieval origins. All persons admitted had to subscribe to the Thirty-Nine Articles of the Anglican communion. Instruction, primarily by tutorials supplemented by occasional lectures by appointed professors, was generally aimed at preparing students for a series of examinations, leading to graduation either in an honours curriculum (Tripos), or, as in Darwin's case, a lower 'pass' curriculum, resulting in a BA degree. For completion of his course of study, Darwin was required to show competence in one of the four Gospels or the Acts of the Apostles in the Greek; in the works of the Anglican theologian William Paley, especially his *Evidences of Christianity*; in Locke's *Essay Concerning Human Understanding*; and in certain writings of Adam Smith, most likely his *Theory of Moral Sentiments*. Mathematical requirements were in the *Elements* of Euclid.¹²

The tradition of the *Autobiography* has characterised Cambridge college life in these years as a leisurely world with little academic rigour. Against that image of Cambridge must be balanced the numerous signs of a vigorous intellectual life, such as the reformed medical curriculum in which Charles' brother Erasmus had enrolled, and the founding in 1819 of the Cambridge Philosophical Society. This society was transforming the scientific culture of Cambridge, sponsoring meetings of Cambridge faculty and graduates to discuss contemporary issues in chemistry, geology, botany, electrical theory, mathematics, optical theory, plant physiology and animal and plant classification. Many of the Fellows and Professors of the university had affiliated with this society by the time Darwin arrived as a student, including the mineralogist and botanist Henslow, the geologist Adam Sedgwick, and the polymath William Whewell, all important as his mentors during these years. Among the other regulars were the chemist Cumming, the anatomist William Clark and the architect of the new medical curriculum, John Haviland. By 1836, the Society had 490 Fellows, with another 58 eminent British and foreign honorary Fellows.¹³

Records from Charles' first year at Cambridge are sparse, and do not give a clear picture of his scientific contacts and interests, though an incipient network of scientific associations was already in place thanks to Erasmus. Their first cousin W. D. Fox was the most important of Charles' early intellectual and social connections. A lifelong correspondence commenced after Fox's graduation in summer 1828.

The early letters reveal that Charles' Edinburgh interests in marine invertebrates were giving way to a passionate study of the local beetles, with Charles making contacts with such leading entomologists as London's F. W. Hope, who would go on to establish the Entomological Society of London in 1833, of which Charles was a founding member *in absentia*.¹⁴

In 1828 Darwin began attending Friday evening meetings at Henslow's apartments. At these meetings, scientifically inclined students met for discussions with senior tutors associated with the Cambridge Philosophical Society (from which students were excluded).¹⁵ Henslow had only recently vacated the chair of mineralogy to take up the Regius chair of botany, and commenced his first course of botanical lectures that spring. In form and content, Henslow's botany course was highly sophisticated for its day, and imported into Cambridge the latest Continental and British botanical theories.¹⁶ The course was particularly modelled on the writings of the Genevan botanist Augustin Pyrame de Candolle, which emphasised both physiological and classificatory botany. Many faculty and students, including Darwin, would attend Henslow's course more than once.

IV THE TRANSFORMATIONS OF 1831

Following the completion of his BA examinations in late January 1831 – he was ranked tenth of 178 candidates¹⁷ – Darwin spent a further two terms in Cambridge to fulfil a residence requirement needed to receive the degree. In this period of leisure, he again attended Henslow's botany course, and a particularly close association developed with Henslow. Plans began to emerge for a post-graduation summer expedition to the volcanic island of Tenerife, in the Canaries, with Henslow and three other students. Most likely under Henslow's tutelage, Darwin now began to read two works by two prominent men of science who would profoundly influence his subsequent thinking: the astronomer John Herschel, son of William, and author of the newly published *Preliminary Discourse on the Study of Natural Philosophy* (1830); and the biogeographer, explorer and interpreter of nature, Alexander von Humboldt, whose *Personal Narrative of Travels to the Equinoctial Regions of the New Continent* recorded the 1799–1804 expedition of Humboldt and his

companion Aimé Bonpland to the interior of South America, with a stop on the way at Tenerife.

Herschel's new book, on the aims, structure, achievements and procedures of science, presented Darwin for the first time with a systematic account of scientific methodology. In the crucial second part of this work, Herschel set forth a theory of how the human mind works in relation to the senses. Secure natural knowledge arises through a process of induction, but this is not passive induction, and Herschel appealed to Francis Bacon's distinction between 'active' and 'passive' observation to make this distinction. Facts are classified under empirical laws, and higher theories, as Herschel wrote, 'result from a consideration of these laws, and of the proximate causes brought into view in the previous process, regarded all together as constituting a new set of phenomena'.¹⁸ Herschel argued that the aim of science was to ascribe certain phenomena to 'true causes' (*verae causae*), 'causes recognized as having a real existence in nature, and not being mere hypotheses or figments of the mind'.¹⁹ From this time forward, the language of Herschel appears in Darwin's writings, and the search for 'true causes' also became Darwin's goal.²⁰

The nature and significance of Humboldt's influence is more elusive, but arguably even more far-reaching, and, in the interpretation of this chapter, decisive in forming Darwin's peculiar understanding of a 'philosophical' naturalist. He likely first learned of Humboldt's theories in detail through Henslow's botany lectures in spring 1831, and the effect was transformative. He speaks of how he worked all morning 'till Henslow's lecture', all the while in his 'head... running about the Tropics: in the morning I go and gaze at Palm trees in the hot-house and come home and read Humboldt: my enthusiasm is so great that I cannot hardly sit still on my chair... I never will be easy till I see the peak of Teneriffe [*sic*] and the great Dragon tree; sandy, dazzling, plains, and gloomy silent forest are alternately uppermost in my mind.'²¹ From Humboldt, more than any other author, Darwin acquired the vision of a comprehensive and holistic science of the natural world, a science concerned above all with *interrelated* phenomena – biological, geological and atmospheric. Humboldtian science sought to determine from 'the arrangement of brute matter organized in rocks, in the distribution and mutual relations of plants and animals' the 'laws of their relations with each other, and the eternal ties which link the phaenomena of life, and those of inanimate

nature'.²² Plant forms were to be related to geography and geology, and the distribution of vegetation was related to the physical parameters of the atmosphere and the physical topography of the land. Humboldt's vision was unlike anything Darwin had previously encountered. It thereafter supplied him with a paradigm of scientific synthesis that connected specific enquiries into detailed phenomena with general theorising on the grandest scale. Just as important, it altered Darwin's sensibility, priming him to experience nature at once conceptually and aesthetically.

The lessons Darwin drew from Herschel and Humboldt applied to science in general. Darwin also acquired a new practical skill in this period. To prepare himself more deeply in geology for the anticipated Canaries expedition, in the spring Darwin accompanied the Regius professor of geology and current president of the Geological Society of London, the Reverend Adam Sedgwick, in a survey of the geology around the Cambridge area. In July, Darwin made his own private geological survey of the region around Shrewsbury. In August he joined Sedgwick in a survey of the geology of north Wales along the Clwyd valley and surrounding areas. He would later recall that this excursion gave him the skills he needed for the geological work of the *Beagle* years.²³ Although the death of a co-organiser put an end to the Tenerife expedition, he did not have long to wait for another opportunity to put those new skills to use. His teachers had recommended him to the Naval Admiralty Office as the ideal person to join HMS *Beagle* on a surveying voyage to the tip of South America. The vessel's young commander, Captain Robert FitzRoy, had requested a gentleman civilian companion, responsible for his own expenses, and knowledgeable in geology, with whom to dine and share interests. When Darwin returned from Wales, a letter of invitation awaited. With the reluctant approval of his father, he accepted the position.

It was in the months of preparation before departure, in the autumn of 1831, that he encountered the work of his third great 'philosophical' mentor, the former barrister and geologist Charles Lyell, through the presentation of the first volume of Lyell's recently published *Principles of Geology* by Captain FitzRoy as the *Beagle* was preparing for its extensive sea voyage. In this first volume Darwin read Lyell's lengthy historical review of the science of geology in which Lyell interpreted the reasons for the failure of the earlier schools of geology to supply a satisfactory account of the geological

history of the earth. Singled out for criticism was the French naturalist George Cuvier, whose synthesis of geological history and palaeontology had deeply influenced Darwin's previous mentors in geology – Jameson, Sedgwick and Humboldt. Later dubbed 'catastrophism', Cuvier's doctrine held that the sudden action of volcanoes, floods, rapid climatic cooling and earthquakes in the past had produced drastic changes in the surface of the earth, resulting in periodic and sudden extinctions of fauna and flora. Against Cuvier, Lyell posed his own 'philosophical' view, which emphasised the 'undeviating uniformity of secondary causes'. After all, quite generally, one is 'guided by his faith in this principle', in judging 'the probability of accounts [...] of former occurrences', and in often rejecting 'the fabulous tales of former ages, on the ground of their being irreconcilable with the experience of more enlightened ages'.²⁴ On the basis of this principle, dubbed 'uniformitarianism' by subsequent commentators, Lyell claimed that the causes of geological changes operating in the past must be assumed to be identical with the causes observed acting at the present, and at the *same intensity*.²⁵ This principle forms the framework within which he analysed the geological and fossil record. Alongside the non-historical and geographical approach he encountered in Humboldt, Darwin now had an authority who had introduced the issue of historical process and temporal causation in a new and exciting way.

Darwin's encounter within one calendar year with three major synthetic scientific thinkers gave him models for a lay scientific career, one tied neither to clerical duties nor to teaching. These three authorities were bold theorists, as well as meticulous describers of natural phenomena, and their theorising received respect rather than disdain from his mentors like Henslow. All of them had been or currently were travellers to exotic places: Herschel was then at the Cape of Good Hope, mapping the southern heavens; Humboldt was a famous explorer of the tropics; Lyell had travelled extensively on the Continent learning its geology. A new vocation was opening before Darwin as he prepared for the *Beagle's* departure.

V UNDER SAIL

After several months of preparation and delays, the *Beagle*, a small man o'war converted into a coastal surveying ship, left Devonport,

England, in late December 1831. It would not return until early October 1836. Although originally intended to be a surveying trip to the southern tip of South America, the expedition eventually turned into a circumnavigation of the globe. The voyage made Darwin into one of the great sea-going naturalists of his era, an explorer in the tradition of Johann and Georg Forster, the father-and-son team who had accompanied the later voyages of Captain James Cook to the South Pacific in the eighteenth century. For fifty-eight months the small ship would be Darwin's primary home and workplace. In its ten-by-eleven-foot poop cabin, housing the library of the *Beagle* – there were around 245 volumes – Darwin carried out shipboard studies of marine organisms obtained by dredging and net hauls, and analysed the geological specimens acquired in his land explorations.²⁶ It was here, too, that he drew up his synthetic reflections in the later months of the voyage.

It is difficult to appreciate in our age of instant communication the degree of isolation this kind of adventure entailed, or the sense of cultural disconnectedness that Darwin experienced on the return home after five years at sea. A letter to Darwin from home and its return response might take as long as eighteen months to complete the circuit. Requests for books and supplies, and their eventual arrival, had to follow the same slow route. The second volume of Lyell's *Principles* (1832), dealing with Lamarckism, biogeography, the birth and death of species and the formation and distribution of coral reefs, reached Darwin remarkably quickly in Monte Video, Uruguay, in late 1832. The third volume (1833), treating in detail the classification of main geological periods, the use of fossil shells to characterise sedimentary rocks, and offering further reflections on the causes of geological change, was received at the Falklands in spring 1834. Other works took much longer to catch up with the ship. Some requested works apparently never reached the *Beagle* at all.

During this period, Darwin's thought developed in ways that are not easy to characterise. As we have seen, he left England well prepared in several areas of science, with a general intellectual formation indebted to several mentors – principally Grant, Henslow and Sedgwick (in person), and Humboldt, Herschel and Lyell (on the page). Naturally enough, Darwin had taken up a number of their beliefs about the world and its proper study. In the course of the voyage, however, he found himself applying, testing and modifying

these beliefs against a set of personal experiences that far transcended those of his teachers and intellectual heroes.

Darwin's development in this period was illustrated in empirical researches and theoretical reflections. His extensive empirical investigations in the *Beagle* years – in zoology, geology and natural history – are recorded in the four bound Zoological Diaries, the three bound Geological Diaries and the ten volumes of 'Notes on Geology of the Places Visited during the Voyage'. More reflective and synthetic observations of places and peoples can be found in the so-called *Beagle Diary*, which formed the basis for the work that made Darwin a public figure, the *Journal of Researches* (1839). In addition to these sources there are the eighteen pocket field notebooks that served as the original records for the *Beagle Diary*; ample correspondence (now published); and the catalogues of specimens. There are also several documents, drawn up on the return leg of the voyage, containing important synthetic reflections on coral reefs, geological formations and the interrelations of geological and biological issues.

During the first leg of the journey, from England to the Cape Verde Islands, off equatorial Africa, Darwin commenced his first 'Zoological Diary', filling it with descriptions of unusual invertebrates collected with a net trawl. He illustrated some of these descriptions with ink drawings of the creatures as viewed under a microscope.²⁷ At the island of St Jago (now Sao Tiago) in the Cape Verdes, where the *Beagle* was stationed from mid-January to early February 1832, Darwin's zoological discussions shifted to studies of land and intertidal invertebrates. It was here that he began his geological notebooks, commencing with a study of the tiny Quail Island in the harbour of Porto Playa on St Jago.

From this date we can follow a developing research agenda into biological and geological issues that was maintained throughout the voyage. His earliest zoological and geological entries at St Jago both employ a similar narrative style of description strongly reminiscent of Humboldt's *Personal Narrative*. His geological records very quickly demonstrate his new practical skills in field geology, and his explanations display his early conversion to Lyellianism. His notes on both zoological and geological issues interweave detailed description and experimental enquiry. There are descriptions of strata, analyses of the superposition of layers of rock, and details of experiments using a blow-pipe and chemical reagents to determine the precise

mineral composition of rock specimens. There are careful descriptions of organisms in a living state and also under experimental conditions. There are discussions of the complex geological layering of formations on Quail Island and St Jago. There are estimates of the probable antiquity of mineral deposits based on the shells of various molluscs – a method worked out in detail in the latter sections of the first volume of Lyell's *Principles*. We find Darwin seeking naturalistic explanations for the layering of geological formations, and appealing to a gradualist, rather than catastrophic, subsidence and elevation of the land.²⁸ There is a discussion of superficial or 'diluvial' layers in which no mention is made of a sudden flood as the cause, a popular belief in British geological circles at the time.

Two general features of Darwin's writings from this time stand out. One is the interweaving of description, causal explanation and reports of occasional experimental enquiries. The other is the roughly parallel treatment of biological and geological topics. Both the interweaving and the parallelism would remain constant through the five years of the voyage. The vastly larger amount of geological writings (1,383 folios) compared to zoological writings (368 folios) reflects in part the different amounts of working time Darwin actually spent on land and sea. His geological descriptions and explanatory analysis were the results of often extended overland journeys, eight of these in South America alone, with one of nine weeks' duration (Valparaíso to Copiaco, Chile). In these investigations Darwin sought to characterise entire regions and their general stratigraphy. In his marine zoological work, by contrast, Darwin was often hampered by poor conditions. Much of the time aboard ship was spent in the rough waters of South America, where cramped working conditions and Darwin's continued sea-sickness prevented sustained concentration. Nonetheless, Darwin's zoological interests were sustained through these years, deeply focused on a few select problems presented by specific groups of organisms, primarily the colonial invertebrates and other 'plant-animals', the same group he had studied as a student in Edinburgh.²⁹

VI SYNTHETIC THEORISING ON THE *BEAGLE*

As we have seen, Darwin had encountered examples of grand, synthetic theorising prior to the *Beagle* voyage. In four examples

between 1834 and 1836, we find Darwin's own efforts to realise similar syntheses. The first of these projects relates to the detailed zoological enquiries. One issue that had attracted Darwin to the study of the 'plant-animals' – the groups forming the colonial marine forms (coelenterates, bryozoans, corals and also the coralline algae) – was the extent to which these creatures truly linked the animal and plant kingdoms together. Several of the works in the *Beagle's* library dealt with the issue, including the zoological works of Lamarck.³⁰ Most authors he read on the topic denied a genuine link between plants and animals. But Darwin's investigations on the *Beagle* led him to the opposite conclusion. In Darwin's view, what unified plants and animals was a common mode of reproduction, centring on the action of 'dynamic' granules found in the protoplasm of colonial animals and plants. In a series of writings between 1834 and 1836, he came to the conclusion that a similar 'granular' matter was found in both the lowest plants and animals and involved in their reproduction, justifying the claim there was 'much analogy between Zoophytes & Plants'.³¹ This theory of a unifying vital matter, often designated 'gemmules' in the *Beagle* documents, would reappear in altered form in 1868 in the hypothesis of pangenesis.

A second example of Darwin's synthetic ambition in the *Beagle* years is his attempt, while he was still in South America, to relate his extensive geological work to biological questions. In a ten-page manuscript written in early 1834 and entitled 'Reflections on Reading my Geological Notes', Darwin summarised his examination of the geology of the eastern side of the South American continent in order to reveal it 'as one grand formation'.³² Appealing to gradual uplift as the primary cause of geological change, but still allowing for the suddenness of its action, Darwin related this elevation of the sea floor to the appearance of life:

May we conjecture that these [repeated elevations] [...] began with greater strides, that rocks from seas too deep for life [...] were rapidly elevated & that immediately when within a proper depth. life commenced [...] The elevations «rapidly» continued; land was produced on which great quadrupeds lived: the former inhabitants of the sea vanished (perhaps an effect of these changes) the present ones appeared «on the new beaches». – The present quadrupeds roamed about [...].³³

In this document, Darwin also queried the origin of the continent's inhabitants – 'from whence came its organized being [*sic*]' – and speculated on how the quadrupeds from south of the La Plata river 'may easily have traveled from their Northern original homes'.³⁴ Rapid elevation also supplied Darwin with an explanation of how species became extinct, or nearly extinct, in Patagonia. The elevation of the land, he wrote, '*seems* to have destroyed them suddenly: though in the South allowing partial re-appearances: if not destroyed highly injurious'.³⁵

A third example of his efforts at integration is the so-called 'Geology Note', composed either on the island of Chiloe or at the port of Valdivia in western South America in February of 1835.³⁶ While on Chiloe in June and July of 1834, Darwin had been deeply impressed with the power of vegetative reproduction in the local apple trees. His interest in the general question of reproductive power and its endurance dated at least from Henslow's botanical lectures.³⁷ With this long-standing interest now re-awakened, Darwin began to explore the extent to which reproductive power was related to issues of geological dynamics, in particular the problem of explaining the extinction of the large 'mastodon' (*Macrauchenia patachonica*, later reclassified as a relative of the camel), whose fossilised remains he had unearthed at Port St Julian in Patagonia in January 1834.

Commenting on Lyell's discussion of the birth and death of species in the *Principles*,³⁸ Darwin struggled with two alternative explanations. The first, attributed by Lyell to the Italian historical geologist Giovanni Brocchi, explained the extinction of species as due to the exhaustion of a finite quantity of life force. On the Brocchian view, species extinction was thus dependent on internal causes, on analogy with the eventual extinction of a vegetative lineage propagated from an apple tree. The other view, favoured by Lyell, related the extinction of species to slow external changes in the physical conditions of existence. In the 'Geological Note', Darwin seems torn between these two explanations. He was now convinced there had been a *gradual* birth and death of species; but he recognised that this fact was consistent with both explanations of extinction. He puzzled generally over the whole notion of some species dying out and other species being born to replace them. As a 'false analogy',

he thinks it plausible that there might be a limited duration of life-force in a species similar to that in apple trees, 'A ~~fact~~ ~~«supposition»~~ in contradiction to the fitness ~~wit~~ which the Author of Nature has now established. – '39 The Brocchian alternative seems to have won Darwin's allegiance by the end of the voyage.

The fourth, and best known, example of Darwin's synthetic theorising is his theory of coral reef formation. His reflections along these lines began while the *Beagle* was still on the South American coast, before the ship had encountered any great reef-building corals, and were probably stimulated by his reading of Lyell's (second-hand) account of the structure and formation of the Pacific coral reefs.⁴⁰ Darwin had been instructed by his mentors before the *Beagle's* departure to learn more about coral reefs. The corals also formed a crucial link between his functional biological investigations on the colonial invertebrates and the geological enquiries.

As Lyell made clear, a satisfactory theory of reef formation required the solution to three issues. First, it needed to explain how coral polyps grow and communicate within a reef. Darwin had been thinking about the general question of growth and communication among colonial organisms for some time, in the course of his studies of the colonial sea fans and bryozoans. In the case of these organisms, the connections between the separate colonies were contemporaneous, while the connections between the components of great coral reefs were largely historical. The second issue to be faced was the need to explain why corals grow where they do, and in particular to explain the relation of reef formation to available light. The third explanatory issue was a problem in geological dynamics: what explains the differences between fringing, barrier and atoll reefs? Lyell, for his part, had proposed that atolls, for example, were formed on the tops of rising submarine volcanoes. More generally, he emphasised the gradual elevation of the sea floor in the formation of reefs.

Except for minor encounters with coral reefs at St Jago in 1832, the east coast of South America and the Galapagos, Darwin's personal acquaintance with the great reef-forming varieties awaited contact with Tahiti on 15 November 1835.⁴¹ Some time following the visit to these islands, he first sketched out his new theory of coral reef formation.⁴² Prior to these reflections, Darwin had adopted Lyell's conclusion on the importance of elevation in bringing coral reefs into

being. Now Darwin struck out on his own, producing a theory that accepted gradual Lyellian mechanisms, but which emphasised the importance of gradual subsidence in the formation of all three forms of reefs.

VII 'LIKE ANOTHER SUN [HUMBOLDT] ILLUMINES
EVERYTHING I BEHOLD.'⁴³

These syntheses provide much insight into Darwin's theoretical pre-occupations and prowess in the *Beagle* years. Just as important are the 'general conclusions' he developed, particularly in the *Beagle Diary*, but also in the Zoological Diaries. These reflections develop the rudiments of a general philosophy of nature in which Darwin sought to integrate the land, sea, forest and landscape, encountered in a holistic experience of nature reminiscent of Humboldt's own reflections.⁴⁴ This personal experience of 'Nature' was an experience that, as Darwin later recalled, was 'intimately connected with a belief in God, [and] did not essentially differ from that which is often called the sense of sublimity'.⁴⁵ Consider his notes to himself on crossing the Andes between Valparaiso and Mendoza Chile in March of 1835:

When we reached the crest & looked backwards, a glorious view was presented. The atmosphere so resplendently clear, the sky an intense blue, the profound valleys, the wild broken forms, the heaps of ruins piled up during the lapse of ages, the bright colored rocks, contrasted with the quiet mountains of Snow, together produced a scene I never could have imagined. Neither plant or bird, excepting a few condors wheeling around the higher pinnacles, distracted the attention from the inanimate mass. I felt glad I was by myself, it was like watching a thunderstorm, or hearing in the full orchestra a chorus of the Messiah.⁴⁶

These emotive responses to the natural world did not shape Darwin's scientific research in a straightforward way. Rather, they reveal the general, holistic tenor of Darwin's reflections in this period, and so throw light on why it is we cannot draw sharp distinctions between 'geography', 'geology', 'zoology' and 'botany' in characterising Darwin's work at this time. Attention to the Humboldtian, integrative dimensions of Darwin's thought likewise makes sense of

numerous *Diary* passages on the relations of thought and matter, the animal and the human, the civilised and the savage. As for thought and matter, in such works as the *Ansichten der Natur* of 1807, and in considerable detail in the later *Kosmos*, Humboldt rejected a sharp distinction between the living and the dead, the conscious and the unconscious, the animate and the inanimate. On animals and humans, in the *Personal Narrative*, the work of Humboldt that Darwin studied most closely in these years, Humboldt wrote of the 'intellectual powers' of monkeys, and of similarities between humans and apes.⁴⁷ And as for the civilised and the savage, Humboldt was also concerned with the relations of endemic and European peoples, and the explanation of the differences between them.⁴⁸

Darwin's remarks on aborigines deserve close attention in this connection, particularly those generated by his encounter with the native peoples of Tierra del Fuego in January 1833 and March 1834. Darwin did not theorise systematically about the Fuegians or other aborigines during these years, and we have no general synthetic document of his views. His *Diary* discussions nonetheless read almost as a kind of dialogue with Humboldt. As Humboldt had concluded after his own encounter with the original peoples, Darwin was impressed with the artistic skills of the Fuegians, which he likened to 'the instinct of animals'. Again with Humboldt, Darwin believed that the Fuegians were 'essentially the same creature' as himself, and yet utterly and profoundly different – 'how little must the mind of one of these beings resemble that of an educated man. What a scale of improvement is comprehended between the faculties of a Fuegian savage & a Sir Isaac Newton! Whence have these people come? Have they remained in the same state since the creation of the world?'⁴⁹ Again like Humboldt, Darwin attributed the diversity of human beings within the one stock to the action of a creative 'Nature', rather than to the traditional Creator of the Bible. 'Nature', Darwin wrote, 'by making habit omnipotent, has fitted the Fuegian to the climate & productions of his country.'⁵⁰ At the other end of the scale, Darwin detected a Humboldtian dynamism and energy, even attributing primitive awareness to extremely low forms of life, as when he writes of how the colonial invertebrate *Crisia* displays a 'co-sensation & a co-will over whole Coralline'.⁵¹ Taken as a whole, the *Diary* entries and stray comments in other materials

reflect an abiding, Humboldtian concern with the place of human beings in nature, and more generally with the relation of consciousness to the panoramic world his *Beagle* adventures were revealing to him.

When the *Beagle* landed at the Galapagos Archipelago in October 1835 for six weeks of sailing between the islands, interspersed with inland geological exploration and specimen collecting, Darwin had already developed considerably as a 'philosophical' naturalist. A long literature, drawing on Darwin's own later autobiographical remarks, has helped sustain a legend that the Galapagos period was crucial for the development of his later theories. In fact, the Galapagos experience was only one, if perhaps the most prominent, example among several encounters with the phenomena of island biogeography. His studies on the Falklands and the Chonos Archipelago had preceded this. The Galapagos experience in itself was neither necessary nor sufficient for the genesis of his later transmutationist views. Indeed, his time in the Galapagos appears to have had little immediate impact on his thinking. It was only after returning to England that Darwin came to emphasise the Galapagos as the site of a major epiphany.⁵²

Notwithstanding the important reflections in February 1835 on species birth and death, there is nothing in the documentary archive of the *Beagle* voyage that maps directly on to the issue of the transmutation of species, not at least as Darwin engaged this issue in his post-voyage notebooks during the spring and summer of 1837. Nonetheless, we can see in the integrative efforts described in the last section, and in the holistic vision of nature outlined in this section, that Darwin the voyager was seeking to synthesise his observations along several lines of enquiry. All of this activity would form the background of his research on his return to England.

VIII 'MY HEAD IS QUITE CONFUSED WITH SO MUCH DELIGHT'⁵³

Following short stops at New Zealand, Australia, the Keeling (now Cocos) Islands, Mauritius, the Cape of Good Hope (where Darwin conversed with Herschel himself), the central Atlantic Islands, Bahia (again), Brazil and the Azores, the *Beagle* reached Falmouth on

2 October 1836. The England he found on disembarking had changed much in his five years of absence. People were travelling widely on railroads; new authorities, many of them German, had entered scientific discourse; new scientific societies had been formed, and others were now flourishing, such as the British Association for the Advancement of Science, founded in the year the *Beagle* sailed. After the isolation of the long voyage, Darwin was understandably eager to share his experiences with others, and to catch up on what he had missed. Not least, there were great piles of journals and books to be read if he was to participate in debates and conversations within the scientific community. His priority was to integrate and connect his detailed investigations cautiously together. Although once planning to become a parson-naturalist, he had now decided on the career of a metropolitan gentleman of science.

It was evident to those who knew him that Darwin had returned as a highly skilled and creative investigator. A public identity as a geologist had been prepared in advance by Henslow's unauthorised publication of geological reflections from some of Darwin's letters of 1834, and by the prior reception of his shipments of South American minerals and fossils. But Darwin's geologising was only one facet of his complex intellectual make-up and rising scientific reputation. His extensive collections of birds, fish, insects and plants won admiration within the Zoological Society of London.⁵⁴ Soon associating with Lyell and with Richard Owen, London's foremost comparative anatomist, Darwin was soon engaged in the analysis of his fossil materials and their relation to geological dynamics.

By early 1837, Darwin was positioned to make the great synthesis of issues for which he is now best known. In the background stood the totality of his experiences and reflections. As he analysed his *Beagle* specimens and notebooks, he was able to draw upon the range of scientific competencies, reflections and inspirations that had filled the past five years. The training of the Edinburgh and Cambridge years; his manifold encounters with strange places and peoples; the revelations of the tropical rainforests that created an experience that Darwin wanted to 'fix for ever in my mind'⁵⁵: all were drawn into the investigations that would occupy him for the next twenty years and beyond. When he wrote, shortly after his return, of